

tau decay systematic: powheg-pythia vs powheg-tauola

Introduction

- We have two powheg ttbar samples, which we think are the same except for tau decay: one uses pythia, the other uses tauola. Pythia ignores the tau polarisation when simulating the decay, while tauola treats it correctly.
- **TTTo2L2Nu2B_7TeV-powheg-pythia6**
TT_TuneZ2_7TeV-powheg-tauola
- The difference between the measured asymmetries when using powheg-pythia and powheg-tauola for the unfolding should give the systematic associated with the mismodeling of the tau decays in powheg-pythia (next slide)

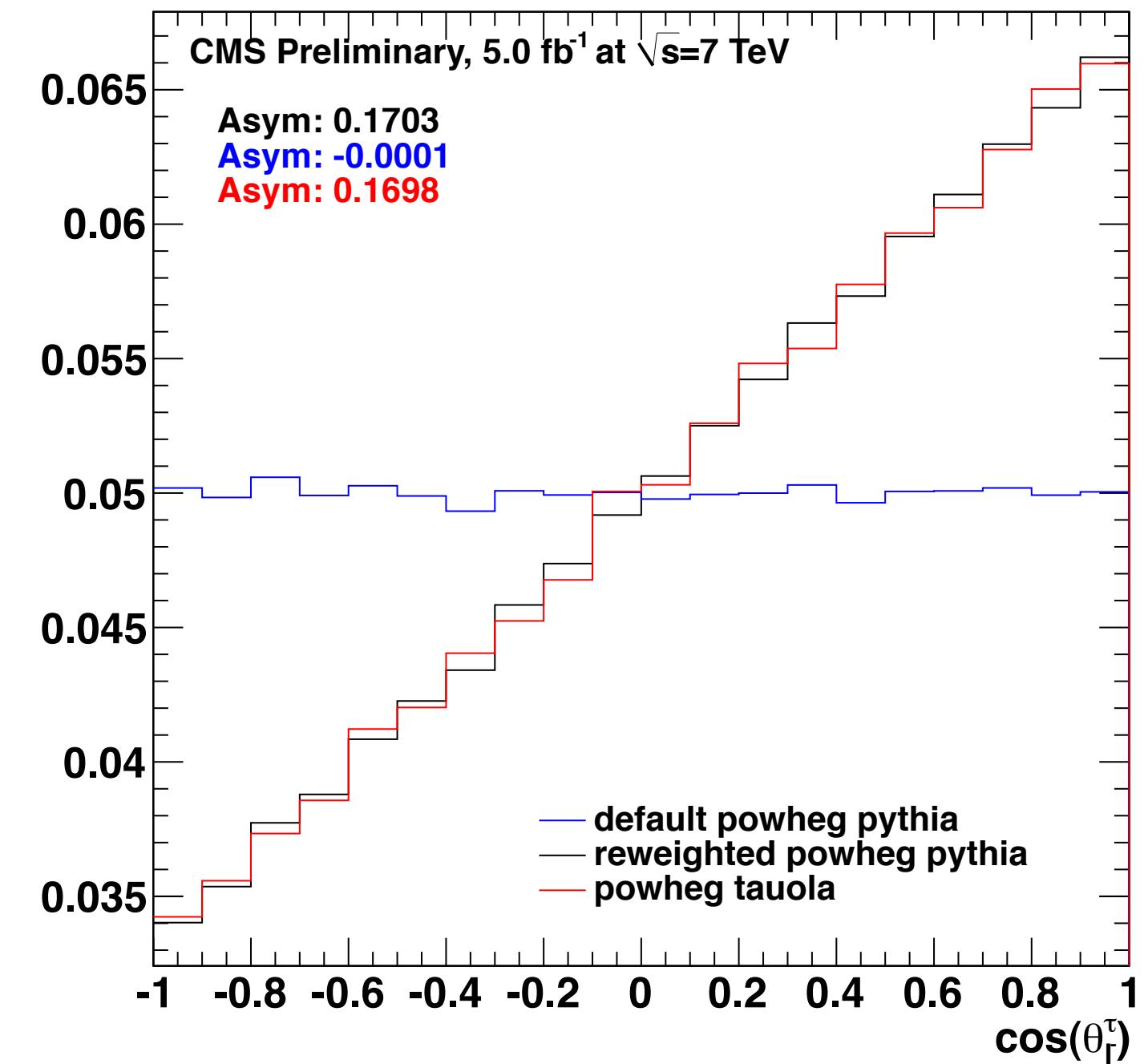
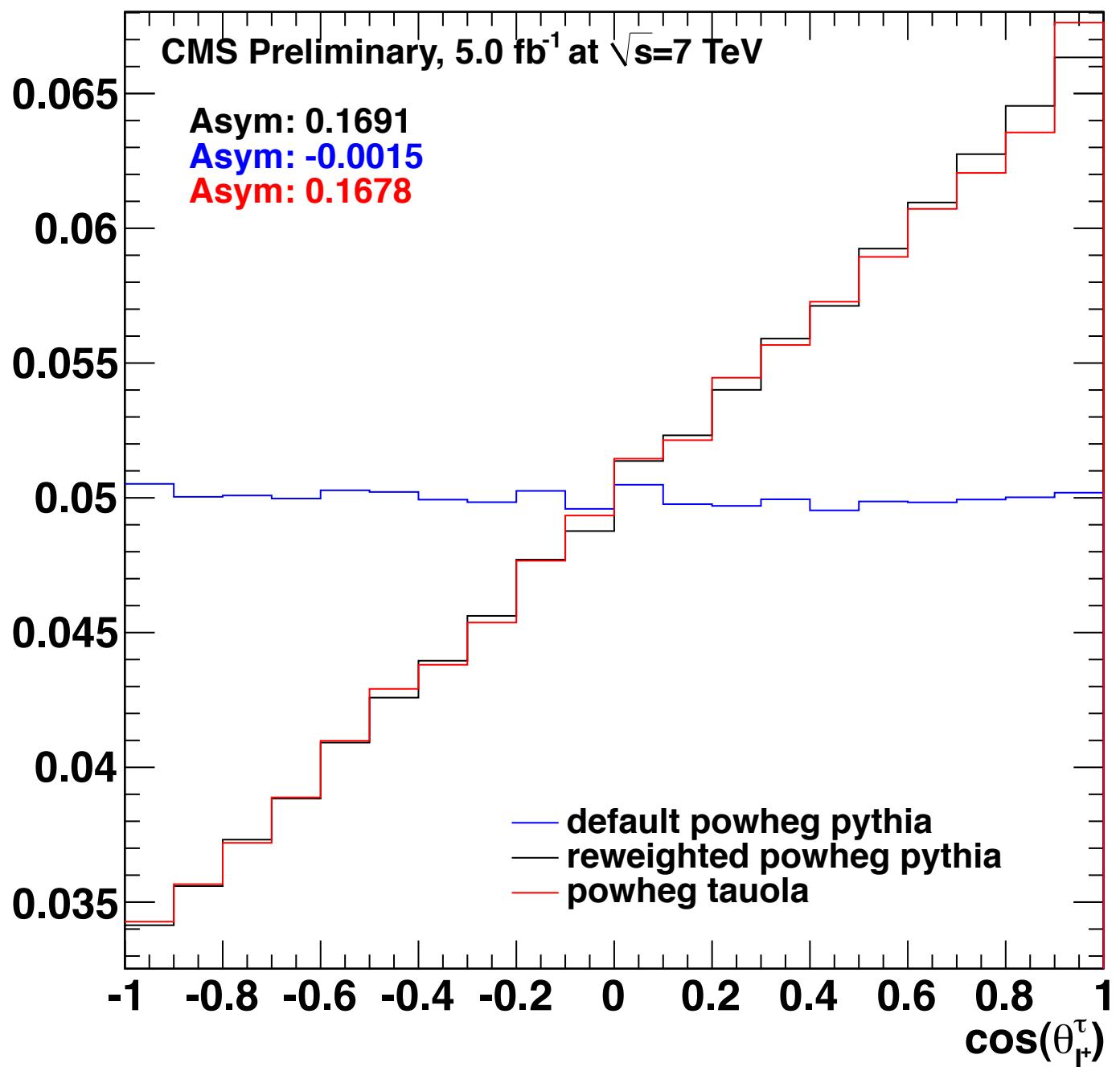
Results (powheg-tauola vs powheg-pythia)

	powheg-pythia results (same as in PAS)	powheg-tauola results	difference
$\mathcal{A}_{\Delta\phi}^{\ell\ell} = \frac{N(\cos \Delta\phi_{\ell\ell} > 0) - N(\cos \Delta\phi_{\ell\ell} < 0)}{N(\cos \Delta\phi_{\ell\ell} > 0) + N(\cos \Delta\phi_{\ell\ell} < 0)}$	-0.097	-0.094	0.0037
$\mathcal{P}_n^+ = \frac{N(\cos \theta_{\ell,n} > 0) - N(\cos \theta_{\ell,n} < 0))}{N(\cos \theta_{\ell,n} > 0) + N(\cos \theta_{\ell,n} < 0))}$	-0.035	-0.024	0.0105
$\mathcal{P}_n^- = \frac{N(\cos \theta_{\ell,n} > 0) - N(\cos \theta_{\ell,n} < 0))}{N(\cos \theta_{\ell,n} > 0) + N(\cos \theta_{\ell,n} < 0))}$	0.019	0.034	0.0148
$\mathcal{A}_{c_1 c_2}^\ell = \frac{N(c_1 c_2 > 0) - N(c_1 c_2 < 0))}{N(c_1 c_2 > 0) + N(c_1 c_2 < 0))}$	-0.015	-0.008	0.0070
$A_{lepC} = \frac{N(\eta_{l^+} > \eta_{l^-}) - N(\eta_{l^+} < \eta_{l^-})}{N(\eta_{l^+} > \eta_{l^-}) + N(\eta_{l^+} < \eta_{l^-})}$	0.010	0.010	0.0002
$A_{topFB} = \frac{N(\cos(\theta_t) > 0) - N(\cos(\theta_t) < 0)}{N(\cos(\theta_t) > 0) + N(\cos(\theta_t) < 0)}$	-0.011	-0.017	-0.0063

- Biggest shift seen in top polarisation
- P^+ and P^- are two independent measures of the top polarisation, using positive and negative leptons
- consistent shifts: systematic = ~0.013

powheg-pythia reweighting

- Try reweighting angular distribution of tau decays in powheg-pythia to reproduce the effect
- Distribution is given by $\frac{d\Gamma(l^\pm)}{d\Omega dx} = \frac{G^2 m_l^5}{192\pi^4} x^2 \left\{ 3(1-x) + \frac{2}{3}\rho(4x-3) + 6\eta \frac{m_e}{m_l} \frac{1-x}{x} \pm \xi P_l \cos \theta [1-x + \frac{2}{3}\delta(4x-3)] \right\}$
- Weight events by $1 + (P \cos \theta (2x - 1)) / (3 - 2x)$ where $x = (\text{lepton momentum}) / (\text{max possible lepton momentum})$ and $\theta = (\text{angle of daughter lepton in tau rest frame})$
- also reweight x distribution to match that of powheg-tauola (this effect is small)



- Powheg pythia distribution looks like powheg-tauola distribution after reweighting

Results (weighted vs unweighted powheg-pythia)

- Now evaluate systematic by unfolding using the reweighted powheg-pythia MC, and comparing to the default

	powheg-pythia r e w e i g h t e d results (same as powheg-pythia difference in PAS)	powheg-pythia difference results	
$\mathcal{A}_{\Delta\phi}^{\ell\ell} = \frac{N(\cos \Delta\phi_{\ell\ell} > 0) - N(\cos \Delta\phi_{\ell\ell} < 0)}{N(\cos \Delta\phi_{\ell\ell} > 0) + N(\cos \Delta\phi_{\ell\ell} < 0)}$	-0.097	-0.097	0.0004
$\mathcal{P}_n^+ = \frac{N(\cos \theta_{\ell,n} > 0) - N(\cos \theta_{\ell,n} < 0)}{N(\cos \theta_{\ell,n} > 0) + N(\cos \theta_{\ell,n} < 0)}$	-0.035	-0.033	0.0019
$\mathcal{P}_n^- = \frac{N(\cos \theta_{\ell,n} > 0) - N(\cos \theta_{\ell,n} < 0)}{N(\cos \theta_{\ell,n} > 0) + N(\cos \theta_{\ell,n} < 0)}$	0.019	0.021	0.0023
$\mathcal{A}_{c_1 c_2}^\ell = \frac{N(c_1 c_2 > 0) - N(c_1 c_2 < 0)}{N(c_1 c_2 > 0) + N(c_1 c_2 < 0)}$	-0.015	-0.015	-0.0007
$A_{lepC} = \frac{N(\eta_{l+} > \eta_{l-}) - N(\eta_{l+} < \eta_{l-})}{N(\eta_{l+} > \eta_{l-}) + N(\eta_{l+} < \eta_{l-})}$	0.010	0.010	-0.0000
$A_{topFB} = \frac{N(\cos(\theta_t) > 0) - N(\cos(\theta_t) < 0)}{N(\cos(\theta_t) > 0) + N(\cos(\theta_t) < 0)}$	-0.011	-0.011	0.0000

- Results show much smaller systematic shifts than powheg-tauola vs powheg pythia (slide 3)
- the largest shift is still seen in top polarisation, and again consistent results are seen between + and - leptons
- also tried simple reweighting (ignoring x dependence), just $I + (P \cos \theta)/3$, and found similar results
- Am I missing some other difference between the two MCs?

check for other differences between the two MC

- If the only difference was in the tau decay, we would see compatible results between the two MCs when excluding events with taus from the unfolding matrices. Results below:

	powheg-pythia results (no taus)	powheg-tauola results (no taus)	difference	difference attributable to tau decay
$\mathcal{A}_{\Delta\phi}^{\ell\ell} = \frac{N(\cos \Delta\phi_{\ell\ell} > 0) - N(\cos \Delta\phi_{\ell\ell} < 0)}{N(\cos \Delta\phi_{\ell\ell} > 0) + N(\cos \Delta\phi_{\ell\ell} < 0)}$	-0.112	-0.107	0.0043	-0.0006
$\mathcal{P}_n^+ = \frac{N(\cos \theta_{\ell,n} > 0) - N(\cos \theta_{\ell,n} < 0)}{N(\cos \theta_{\ell,n} > 0) + N(\cos \theta_{\ell,n} < 0)}$	-0.065	-0.059	0.0063	0.0042
$\mathcal{P}_n^- = \frac{N(\cos \theta_{\ell,n} > 0) - N(\cos \theta_{\ell,n} < 0)}{N(\cos \theta_{\ell,n} > 0) + N(\cos \theta_{\ell,n} < 0)}$	-0.015	-0.003	0.0123	0.0025
$\mathcal{A}_{c_1 c_2}^\ell = \frac{N(c_1 c_2 > 0) - N(c_1 c_2 < 0)}{N(c_1 c_2 > 0) + N(c_1 c_2 < 0)}$	-0.003	0.008	0.0111	-0.0042
$A_{lepC} = \frac{N(\eta_{l+} > \eta_{l-}) - N(\eta_{l+} < \eta_{l-})}{N(\eta_{l+} > \eta_{l-}) + N(\eta_{l+} < \eta_{l-})}$	0.010	0.011	0.0007	-0.0005
$A_{topFB} = \frac{N(\cos(\theta_t) > 0) - N(\cos(\theta_t) < 0)}{N(\cos(\theta_t) > 0) + N(\cos(\theta_t) < 0)}$	-0.010	-0.017	-0.0067	0.0004

- Still a significant difference: most of the difference between the two MCs is independent of taus!
- Difference attributable to tau decays (final column) calculated by comparing “difference” column to slide 3. Results are compatible with results from reweighting powheg-pythia (slide 5).

powheg pythia vs tauola, parton level, no cuts

	powheg-pythia	powheg-tauola	difference	
$\mathcal{A}_{\Delta\phi}^{\ell\ell} = \frac{N(\cos \Delta\phi_{\ell\ell} > 0) - N(\cos \Delta\phi_{\ell\ell} < 0)}{N(\cos \Delta\phi_{\ell\ell} > 0) + N(\cos \Delta\phi_{\ell\ell} < 0)}$	-0.119	-0.117	0.0011	± 0.0012
$\mathcal{P}_n^+ = \frac{N(\cos \theta_{\ell,n} > 0) - N(\cos \theta_{\ell,n} < 0)}{N(\cos \theta_{\ell,n} > 0) + N(\cos \theta_{\ell,n} < 0)}$	0.003	0.004	0.0013	± 0.0012
$\mathcal{P}_n^- = \frac{N(\cos \theta_{\ell,n} > 0) - N(\cos \theta_{\ell,n} < 0)}{N(\cos \theta_{\ell,n} > 0) + N(\cos \theta_{\ell,n} < 0)}$	0.003	0.003	0.0001	± 0.0012
$\mathcal{A}_{c_1 c_2}^\ell = \frac{N(c_1 c_2 > 0) - N(c_1 c_2 < 0)}{N(c_1 c_2 > 0) + N(c_1 c_2 < 0)}$	-0.063	-0.062	0.0006	± 0.0012
$A_{lepC} = \frac{N(\eta_{l^+} > \eta_{l^-}) - N(\eta_{l^+} < \eta_{l^-})}{N(\eta_{l^+} > \eta_{l^-}) + N(\eta_{l^+} < \eta_{l^-})}$	0.004	0.004	0.0002	± 0.0012
$A_{topFB} = \frac{N(\cos(\theta_t) > 0) - N(\cos(\theta_t) < 0)}{N(\cos(\theta_t) > 0) + N(\cos(\theta_t) < 0)}$	0.005	0.005	0.0002	± 0.0012

- As expected, the two MCs are statistically consistent at parton-level when no cuts are made (using status 3 taus)
- There must be other differences besides taus in the decay, but nothing obvious in config files or in PREP:
 - http://cmssw.cvs.cern.ch/cgi-bin/cmssw.cgi/CMSSW/Configuration/GenProduction/python/POWHEG_PYTHIA6_ttbar_1nub1nub_7TeV_cff.py?hideattic=0&revision=1.6&view=markup
 - http://cmssw.cvs.cern.ch/cgi-bin/cmssw.cgi/CMSSW/Configuration/GenProduction/python/POWHEG_PYTHIA6_top_tauola_cff.py?hideattic=0&revision=1.2&view=markup
 - http://cms.cern.ch/iCMS/prep/requestmanagement?dsn=TTTo2L2Nu2B_7TeV-powheg-pythia6&campid=Summer11_RI
 - http://cms.cern.ch/iCMS/prep/requestmanagement?dsn=TT_TuneZ2_7TeV-powheg-tauola&campid=Summer11_RI

Conclusions

- There is a significant systematic difference between the powheg-pythia and powheg-tauola samples for the polarisation measurement
- Only a small amount of the difference ($\sim 25\%$) is attributable to tau decay modeling
 - what other difference between the two MCs could I be missing?
- The true systematic from tau decay modeling is small for all our variables
- May be OK to use MC@NLO for the paper?